

“ST26733”, International Conference "Agriculture for Life, Life for Agriculture"

A New Concept for Seed Precision Planting

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Abstract

Mechanically driven seed metering devices currently perform their function efficiently and are a good solution to the problem of metering rates as seed is planted, but there are many voids that could be filled with a substantial change to the metering process. Electronically controlled seed singulation devices can address many of the inefficiencies experienced in a mechanically driven seed metering device and have the potential to increase productivity and yield rates dramatically. This research involves the process of designing, developing, and testing the feasibility of an apparatus used to precision place single seeds in a furrow during a planting operation. The equipment incorporated is a linear solenoid actuator connected with a special draw not used with any current seed metering device yet. The design uses an electronic device (based on 555 timer) to assist the solenoid in one movement (the forth movement of the draw), the back movement being accomplished by a spring. An optical electronic device was developed to trigger the 555 timer and the solenoid. This prototype gives a glimpse of what is possible in the future of seed singulation.

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Peer-review under responsibility of the University of Agronomic Sciences and Veterinary Medicine Bucharest

Keywords: precision planting, seed metering, coated seed, automation, electronics, optical-electronics.

1. Introduction

The current methods for seed placement in row planting equipment is accomplished with a variety of mechanically driven devices, typically driven by a wheel in contact with the ground or hydraulic motors. Providing mechanical power to drive seed metering devices through these methods is a cost effective and reliable solution.

The method of driving the metering devices is by the use of a common drive shaft powered by a ground driven wheel, varying metering rates in relation to the implements ground speed. Planters could also use a hydraulic motor

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which controls metering rates by varying the flow rate provided to the motor. The size of a set of row units is typically around eight row wide sections, meaning that all eight row units must be either on or off and must be planting at the same population rate across the section. It is possible to turn each row unit on or off, but this requires a clutching system at each row. This allows any row to be shut off as desired, but the system to do so is mechanically complicated and expensive. Therefore, this system is rarely present in most planting implement.

A further drawback of the mechanical metering devices is the bulkiness of the system. With such a large space required to accommodate the metering devices, they must be mounted above the actual planting components of the row unit. The seed is then transferred to the furrow created by the opening discs, via a seed tube. While the seed transitions from the metering device to the furrow through this seed tube, variability in the seed spacing can occur. This variability occurs from bouncing of the seeds and vibrations that are induced on the row unit as it travels through the field. The final drawback of the mechanically driven system is the lack of communication of seed placement between row units on an implement. On current metering designs, the system has control over only the seeding population, but not the actual timing and placement of the seed. This means a seed is dropping into the furrow at a constant rate, but the row unit cannot detect the time and place where a seed is being placed relative to its neighboring row units.

Electronically controlled seed singulation devices can address many of the inefficiencies experienced in a mechanically driven seed metering device and have the potential to increase productivity and yield rates dramatically.

Planters that meter individual seeds provide the most precise control of seeding rates. However, according to Hunt (2001), field tests of planters show substantial variability of seed spacing in a row. This variability can be attributed to several factors. Some cells in a seed meter may fail to fill or may contain more than one seed due to variation in individual seed size. Also, in ground driven metering devices, wheel slippage can affect the seeding rate.

Several studies have been performed on the performance of row-crop planters, as well as new devices for improving single seed selection. Previous experimenters studying vacuum planters have used several kinds of seed pickup elements, such as nozzles, drum perforations, vacuum plate, and suction ports on a wheel periphery (Persson and Sial, 1984).

Halderson (1983) evaluation of several commercial row crop planter units for their seed metering ability in selecting single seed showed that (a) none of the planters examined could maintain seed selection accuracy within 5% as planting speeds increased, (b) all planters could achieve 95% accuracy under certain conditions – primarily low speed, (c) as planting speed increased, accuracy tended to decrease, and (d) precision of seed spacing in the furrow could best be described as random under the conditions of these tests, although there were differences between machines.

Mechanically driven seed metering devices currently perform their function efficiently and are a good solution to the problem of metering rates as seed is planted, but there are many shortcomings and voids that could be filled with a substantial change to the metering process. A proposed solution to fill these voids can be accomplished with an electronically driven and controlled actuation system to meter seed. A successful operating system addresses the problems stated above and be able to improve or add the following features to a planting implement's seed metering device:

- Provide accurate metering of seed rates equal to or better than current metering devices.
- Reduce the overall size of the metering device and place it closer to the ground.
- Eliminate the mechanical components required to drive current meters and/or clutch systems necessary to control the units on a per row basis.
- Improve compatibility between row units on seed placement and seed population rates using electronics.

Development and design of an electronically actuated seed meter would have the capability to meter seed population at a level equal to that of current equipment or devices available on the market. The improved accuracy of the new seed metering device will make it more marketable to farmers.

To improve metering accuracy, the focus was to eliminate seed doubles or blanks as the seed is placed in the furrow.

A further rationale for the development of an electronically controlled metering device is the potential to reduce the overall size of the metering device. The seed meter has the potential to reduce its overall size greatly with the incorporation of electronic actuation in the system. In current equipment, a major limiting factor on the size of the

meter is the vacuum plate seed disk required to accomplish the singulation process. These vacuum disks work in cooperation with negative air pressure to pick and place single seeds into the seed tube. Incorporating such a large component into the design limits the placement of the seed meter to areas above the actual working components of the row unit.

With the incorporation of electronic components into the metering device, the bulky seed disk can be eliminated from the design, but the elimination of this component also removes the drive mechanism necessary to power the seed disk. Removing these parts from the design can allow the metering device to be much more compact, allowing it to be installed in a variety of new locations on the row unit. The intention of a new design is to reduce the size of the device to allow it to be mounted as close as possible to the furrow opener (or even in it).

Incorporating electronic components into the metering device, the large mechanical components that are currently used in the seed singulation and metering process could be eliminated. This includes the common drive shaft that would power a section of row units, the variable rate adjustments, and the hydraulic drive motor or ground powered drive wheel/sprocket system.

With the mechanical drive system eliminated from the new metering device, a new source of actuation power is necessary. To power and drive the future design, the focus is to use electronic solenoid actuation, leading towards linear electric actuators. Incorporation of electronic solenoids to power the metering device gives the ability to break away from the common drive system. With each row unit individually controlled, the electronic control system is able to verify that the required amount of seed is going down independently from other rows. If coupled with GPS, it will allow precise placement of seed along the row reducing overall seed usage.

The final and most significant benefit that is gained with electronic actuation is the ability of compatibility between row units. Currently the methods of metering and seed singulation are only capable of controlling the rate of seed placement. It is unknown exactly when a seed is being placed into the furrow. With the electronic system controlling placement, it can be determined when a seed is placed in the ground. For example, when the solenoid is energized, the system activates moving a seed to the seed tube and it is determined exactly when that seed is placed in the furrow. Allowing the system to control the exact point of seed placement, planting patterns can be created in the field during seeding operations.

2. Materials and Methods

The main objective of this research was to study and develop the new concept of electronically controlled seed singulation. The specific objectives are stated below:

- To use electronic actuation in conjunction with gravity to singulate seed.
- To reduce the overall size of the existing metering device, allowing a more compact design with the intention of mounting the metering device closer to ground, reducing the overall space travelled by a seed from the device to the ground.
- To allow communication or collaboration between row units, allowing precise and accurate placement and seed patterns to be created during planting.

To be considered versatile, a further target has to be achieved by this new prototype of metering device. With a vast variety of shapes, dimensions and weights of agricultural and horticultural seeds, a conclusion had to be fulfilled and this was to use coated/pelleted seeds of spherical shape.

3. Results and Discussions

First of all why pelleted seeds. The modern tendency for pelleted seeds, especially in Europe, is to get a more spherical shape finally, regardless of the type of the raw seed (shape, size, surface). Pelletting is the process of coating seeds with inert materials to make them uniform in size and shape. Pelleted seed allows for greater accuracy and results in a more efficient seeding process. Seeds are pelleted by tumbling them with the coating material and gradually adding moisture. Once the pellet coating reaches the desired size, the pelleted seeds are cured (dried).

Pelleting improves the shape, size, and uniformity of raw seeds for more accurate sowing by hand and precision-sowing by machine. The use of pelleted seed results in a more uniform stand, less seed actually being used, and less time spent thinning.

The pellets are made of inert materials which dissolve as they absorb moisture, allowing immediate access to oxygen for fast, uniform seedling emergence.

Because of its uniform size and shape, pelleted seed is less likely to become jammed or stuck in mechanical planters, allowing growers to accurately singulate and efficiently plant direct-seeded crops. Accurate seeding and seed spacing makes thinning stands easier or even unnecessary, leading to less seed waste and lower labor costs. Pellet coatings are often used as a vehicle for seed treatments. This helps to keep the treatment near the seed during the germination period. In addition, pellets make many smallseeded crops, such as lettuce, carrots, and some flowers, easier to handle in general, so even if not planting on a large scale, pellets can be useful.

Pelleting offers many advantages, but this process also shortens the shelf life of the seed. Pellets come in a variety of densities and sizes. Pellet densities range from low to medium to high, with low-density pellets being the lightest and high density pellets being the heaviest.

The design of the new metering device consists of a single sliding hopper (drawer) actuated by a plunger of a solenoid, which is triggered by an electronic device. The principle of the new metering device is presented in figure 1.

In the idle position the drawer is not moved by the plunger of the solenoid, the hole in the drawer is aligned with the seed tube connected with the seed tank and permits only a single seed to fill space.

In figure 2 the seed is taken up by the drawer and headed towards the exhaust tube; the recovery spring is then contracted.

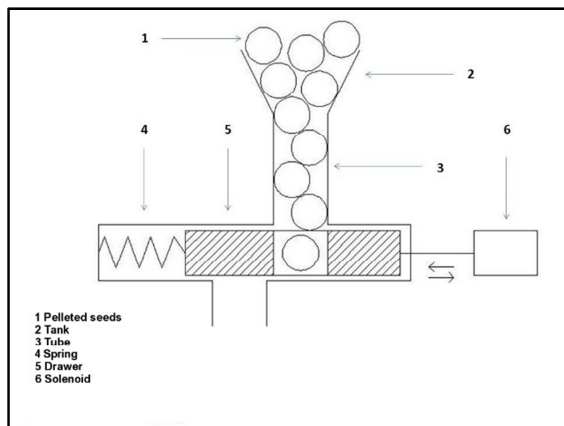


Fig. 1. The principle of the metering device.

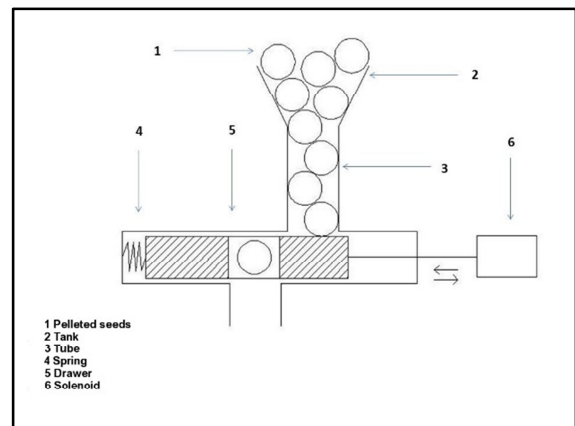


Fig. 2. The seed is delivered to the exhaust tube.

When the drawer reaches final position of the movement, it aligns with the exhaust tube and the seed under gravity force leaves the drawer space and falls into the ground (Figure 3).

After seed is leaving the space in the drawer the action of the solenoid is cut off and the spring is pushing back drawer in its initial position where a new pelleted seed is entering the hole.

The prototype of the optoelectronic control device is based on an electric scheme of electronic switch control through optical sensor, which works in the field of infrared. Optoelectronic sensor, which plays the role of circuit breaker, is composed of a IrLED diode (D1 in Figure 4) and a phototransistor (T1 in Figure 4), which enters into conduction when IrLED diode radiation "illuminates" transistor. If between the diode D1 and phototransistor T1 is interposed an obstacle and the light beam is interrupted, the transistor hangs; when the obstacle is removed light beam brightens again phototransistor and this enters into conduction again. In this way a classic switch with "open" and "closed" positions is done electronically.

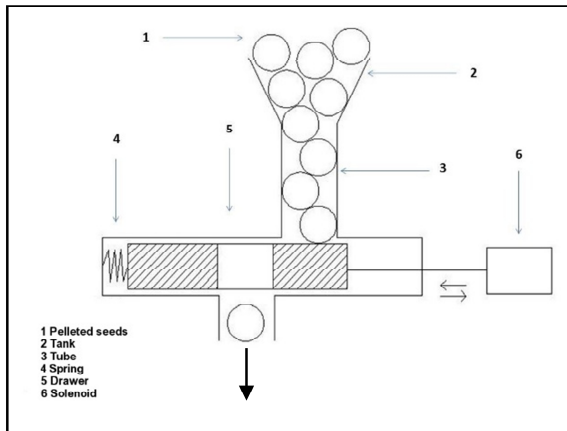


Fig. 3. Under gravity force seed is leaving the device.

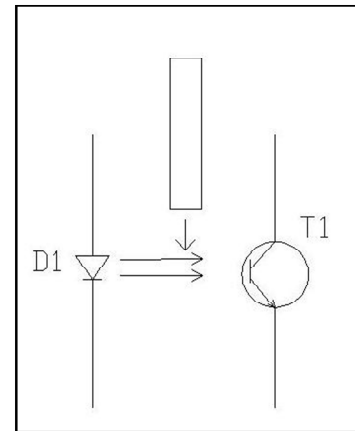


Fig. 4. The principle of an optical coupler (switch).

If we can associate the two positions **conduction = closed switch** and **locked = open switch** and power the electromagnetic coil of the solenoid, which is actuating the drawer of the metering device, we can achieve two extreme positions of the drawer “get seed” and “release seed”. These positions are shown in figure 5.

The two active electronic components (**D1** and **Q1**) are built in the form of a single functional block (also called optical slot sensor) and are arranged to be coaxial. Blocking or releasing the slot between the two optoelectronic devices (D1, T1) with a slotted disc ensure the electronic circuit sudden switching from blocked into state of conduction.

The electronic circuit itself (Figure 6) is based on an integrated circuit type $\beta E 555$ or similar, which operates the coil of the solenoid when is commanded by the optical sensor.

The slotted disc with different number of slots and the position between D1 and T1 is shown in figure 7. Disc with opaque slots is mounted on the axis of gear wheel and is driven by a simple chain transmission, which connects this disc to the ground wheel of the precision planting machine. When different numbers of seeds are sown per hectare the only thing to do is to change the disc with slots or to change the wheels of the chain transmission (transmission ratio).

With this new concept a single electronic device can operate as many planting units as is needed (4, 6 and 8 being the most popular) as shown in figure 8.

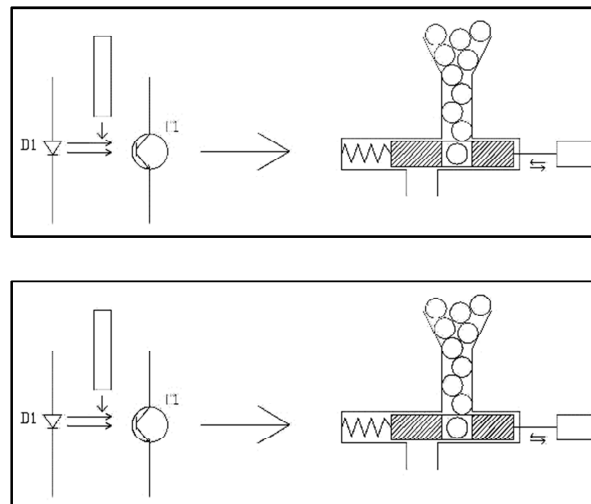


Fig. 5. “Get seed” and “release seed” connection.

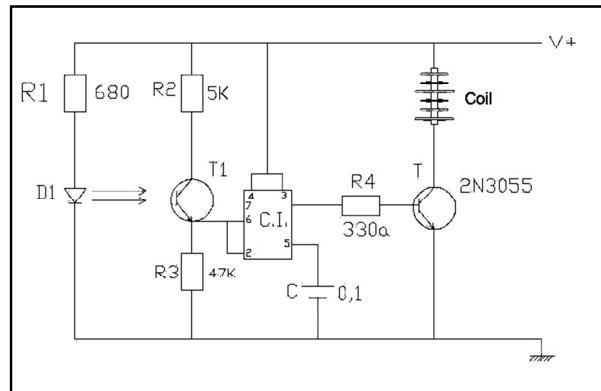


Fig. 6. The electrical scheme of the circuit.

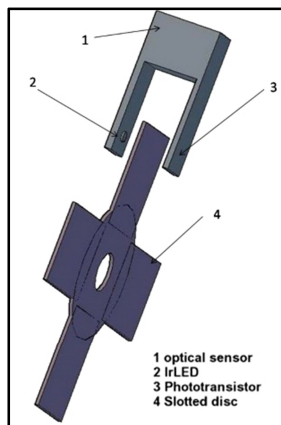


Fig. 7. Blocking and releasing the gap of the optical sensor by the slotted disc.

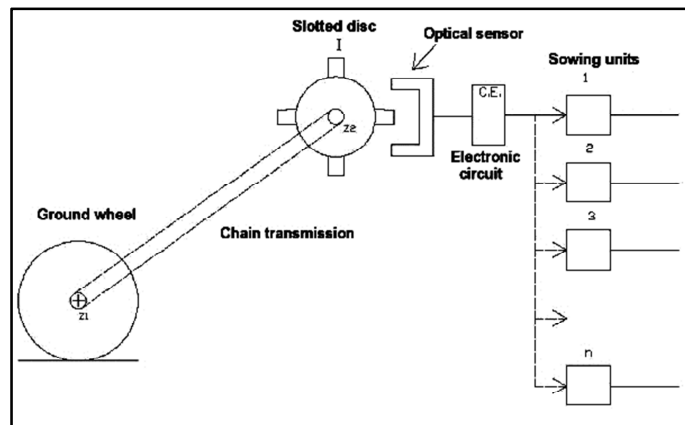


Fig. 8. The principle of operation of the new concept of electronically driven precision planter.

4. Conclusions

- The research proved that electronic linear actuation can be used for seed singulation.
- Used electric current in conjunction with gravity to move seed.
- Reduced overall size of a metering device to allow row unit placement closer to the ground to obtain a far better uniformity.
- Electronic control provides the capability for communication and connections among row units.
- The actuator chosen for the final design was cost effective for the customer to use
- Reduced the number of transmissions to a minimum.
- Different patterns can be obtained in sowing single seeds.
- Pelleted seeds is the option for future sowing.

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